Options for the management and recycling of disposable diaper waste in Zimbabwe's urban areas

Sian Magadza
Faculty of Science and Technology
Zimbabwe Open University
E-mail:sianmagadza

Abstract

Disposable diaper and other absorbent hygienic products (AHP) form an increasing quantity of the solid waste generated in Zimbabwe's urban areas. This form of waste poses a problem as it is not biodegradable and can be a health hazard. This study identifies ways to deal with disposable diaper waste and evaluates their possible usage in the context of Zimbabwe. Alternatives to disposable diapers and recent developments in some countries in collection of used diapers and their recycling are identified through a search of relevant literature. The possible applicability of these strategies is evaluated through observations and analysis of areas elsewhere in the World where these strategies have been used. Group discussion with mothers were undertaken to share perceptions on the viability and logistics of collection and recycling schemes within the Zimbabwean context. Further research areas were identified.

Key words: Absorbent Hygienic Products (AHP),diaper, recycling, Zimbabwe

Background to the problem

Nappy use

Absorbent hygienic products (AHP) form a large proportion of global landfill. AHP products consist of disposable child and adult diapers and women's sanitary waste. Of these the least biodegradable and bulkiest are the diapers, especially as most diapers contain cellulose fibres and water absorbent polymer, sodium polyacrylate (SAP) designed to absorb liquid excreta (Aumonier and Collins, 2008) as well as plastics, adhesives, cotton and other material. It has been found in studies that a child uses an average of 4000 diapers before they are potty trained (Smedley, 2014). Diaper waste in countries such as Britain and the USA, may account for 4% to 7% of black bin waste (ibid) and they are the third largest individual constituent of municipal solid waste, being estimated at somewhere between 1.5% and 4% of the total (Pham and Brown, 2009; Friends of the Earth, 2007; Rapson and Rolls, 2010). Aumonier, Collins, et al., (2008) estimated that an average child will use 146.5kg of diapers over a two and a half year period, averaging 4.16 diapers per day. This generates a sizable disposal headache. While there is a decrease in family size in many economically developed countries (EDC), the reduction of children in diapers is offset by an increase in the elderly population with a corresponding growth in adult diaper usage for the infirm.

In much of Africa, and in Zimbabwe in particular, use of disposable diapers is a growing trend. Disposable diaper use in urban areas appears to have overtaken the use of reusable 'terry' diapers. In a study by Sola (2014) focused on Pumula South, a high density suburb in Bulawayo, Zimbabwe's second largest city, it was shown that 28% of mothers sampled used disposable diapers

exclusively. A further 50% used both types of diapers, and only 22% used reusable 'terry' diapers alone. Zamba (2014) in a study of solid waste generation by households in Mbare, Harare, found that 15% of solid waste generated and placed for curbside collection consisted of disposable diapers. This appears to be greater than the 4% to 7% mentioned from overseas studies and could be due to Zimbabweans tending to consume fewer packaged goods than their European and American counterparts. There is evidence that the trend of using disposable diapers is also permeating into some of the rural areas, particularly among rural based professionals like teachers and where people have spouses or close relatives who send them diapers from where they are based in urban areas and cross-border countries (discussions with mothers, 2014). Disposables are seen as more convenient, easier for travel, and more absorbent and, therefore, better for night time use (Mangizvo, 2014; Sola, 2014). Monetary concerns seem to be the main inhibiting factor against the use of disposables, with most non users citing cost rather than environmental or other concerns as the main reason why they have remained using reusable cloth diapers (Sola, 2014). Sola's study found that mothers used an average of 25 disposable diapers a week and that this was costing on average $13.61, although this might vary considerably depending upon the type, brand and method of sourcing.

Africa, of which Zimbabwe is part, is seen as a growing market for disposable diapers. A report from McKinsey's Africa Consumer Insights Centre (Hattingh, Russo, et al., 2012) cite diapers among examples of promotion of products within Africa by large companies, stating that Procter and Gamble who manufacture 'Pampers', used a mobile-health clinic programme to connect with more than 100,000 mothers with babies in fifty towns across Nigeria. 'The clinics offered free baby care and hygiene education, health check-ups, and diaper samples'(Hattingh, Russo, et al., 2012:12). Obviously this was attractive to mothers and effectively exposed them to disposable diaper products. PEP stores of South Africa proudly state in their fact sheet (Pep, 2013) that they 'sell 4 disposable nappies every trading second-and 35 million nappies every year'. These examples reflect the growing market for disposables and the aggressive marketing that may be increasingly conducted by companies wishing to collar a share in the market, and increase their consumer base. In comparison to the two examples, which link to two of the countries with the largest populations in Africa south of the Sahara, Zimbabwe is a small, but growing market. However, it might be expected that promotion of disposable nappies through aggressive marketing within countries such as Zimbabwe, is likely to increase. It is in the light of this, that studies have shown the use of disposables to be considered fashionable and giving a certain status to the mother using them (Mangizvo, 2014). A high demand for disposable diapers in Zimbabwe is reflected in their presence in a variety of retailing sources, ranging from wholesale and large supermarkets to flea markets and tuck shops (The authors' observation, 2014). Local production is limited to one company, Farai products, who form a very small part of the sector. However, there are new initiatives such as a group of women who have bought a diaper making machine and are hoping to launch affordable locally made disposable diapers into the local market. These diapers will use locally available cotton material rather than super absorbent polymers (SAP) and may be easier to compost. Therefore, the use of disposable diapers also represents a large drain on the country's monetary resources, spent to import a product which ultimately results in nuisance landfill.

While there appear to be no studies that attempt to estimate total disposable diaper use in Zimbabwe, it is obvious that levels of use are rising. Indications suggest that as the Zimbabwean economy improves disposable diaper use will increase further.

Impact of disposable and re-usable diapers on the environment

Many studies have been done attempting to gauge the relative impact of disposable and reusable diapers on the environment (Aumonier and Collins, 2005; Aumonier, Collins, et al 2008; Meseldzija, Poznanovic et al, 2013). Lifecycle studies show that both forms of diaper have a serious impact. Lifecycle studies are complex and have mostly been conducted in the more industrial countries where conditions may be at significant variance from those found in countries like Zimbabwe. In the case of re-usable diapers, the greatest impact is seen to be in the initial manufacturing process. However, there are also impacts related to the disposal of excreta and in the laundering process (high water consumption and detergent use). Disposable diapers have impacts related to initial production, but also, most seriously, in the disposal of the used diaper. Some sources believe both forms of diaper to be seriously environmentally detrimental (Schoch, 1996). Estimates of excreta produced over the two and a half years of a child's lifetime vary between 365 Kgs (Aumonier and Collins, 2005) and 727Kgs (WRAP quoted in Aumonier, Collins, et al, 2008). In both types of diapers the excreta, which contains pathogens (Rapson and Rolls, 2010), has to be disposed of, usually with the diaper in the case of disposables and normally down the toilet and into the sewage system in the case of reusable diapers. In both cases the excreta poses a potential health hazard.

A quick on-line search reveals the emotive nature of the disposable versus re-usable debate, with pressure groups, environmentalists, manufacturers, discussion groups and blogs all wishing to promote their points of view. In the economically developed countries re-usable diapers account for just 1.4% of the market by sales value (Rapson and Rolls, 2010).

In Zimbabwe and many other African countries, the environmental debate needs to be considered in relation to the conditions faced in urban areas. The problems associated with both disposable and reusable diaper usage are greater because of municipal restraints and service breakdowns. While on the surface, use of reusable diapers would seem more environmentally friendly, the benefits are cancelled out where water provision breaks down and effective laundering of diapers cannot take place. In this scenario not only are more cloth diapers needed to cater for longer intervals between laundering, but also there are serious health implications in storing soiled diapers over longer periods. The storing of used disposable diapers also poses a health risk. At present most municipal authorities collect refuse at weekly or fortnightly intervals. This results in the build-up of diaper waste in the home, and may be particularly serious in a high density situation and where more than one family shares a housing unit. In these situations and particularly where municipality service breakdowns mean a delay in collecting waste, dumping of diaper waste in vacant areas near housing and in peri-urban bush occurs (Sola, 2014; Mangizvo, 2014). This creates a public health hazard, as children play with and alongside the waste, dogs and wild animals may disperse it over a wider area, bad odours and water contamination above and below the surface may occur. Mothers report refusal of Bulawayo municipal waste collection to receive diaper waste if it is mixed with other waste and not placed in sealed bags (discussions with mothers, 2014). Those who do not have suitable bags or who are uneducated about the procedure, resort to other methods of disposal, mainly dumping. Clearly there are serious environmental and health problems at household level associated with the use of either form of diaper. Problems of disposable diapers at municipal landfill sites result from the simple form of

landfill used, where all wastes are bundled together and incineration facilities are unavailable. Waste pickers and those municipal employees working directly in waste disposal are vulnerable to illnesses linked to their exposure to excreta (Mangizvo, 2014).

The research problem

Although disposal of used diapers is a serious and growing problem internationally, very little research is documented addressing solutions, and identifiedinformation is mostly fragmented. In Zimbabwe disposal of used diapers is a visible problem that has not yet been addressed. In order to evaluate possible options for disposal in Zimbabwe, this paper seeks to bring together information on the various attempts made internationally to dispose of this type of waste. It also seeks to evaluate the applicability of identified possible strategies, for use in the Zimbabwean context. It is hoped that this will form a base from which to select, and experiment with, solutions.

Review of related literature

'Diaper' is an American term for an incontinent product designed to collect and absorb waste emitted from the body (adapted from Zwane, 2010). In some countries such as Britain the term 'nappy' is used rather than diaper.

Many studies concerned with solid waste management fail to consider diaper waste as distinct from solid waste. Diapers are difficult to categorise into waste type as they have a number of distinct components, some of which may be easier to break down and recycle than others. Paper pulp, super absorbent polymers (SAP), plastics and waterproofing, are present in most commercial diapers (Pham and Brown, 2009; Lehrburger, 1988; Appropedia, 2010). A used diaper may contain more than 60% urine (Pham and Brown, 2009) and/or excreta.The difficulty associated with the multiple natures of diaper components, presents a disposal headache. What most municipal authorities agree on, is that used diapers present a health risk. In places where refuse is now separated at source (most More Economically Developed Countries, MEDCs) refuse may be divided into different 'carts' or collection receptacles. These may be a general refuse cart, a recycling cart, a compost cart, or various versions of these (City of Ann Arbor, 2013). However, up until recently, used diapers were considered part of general refuse. Because of the nature of used diapers, refuse collection authorities require used diapers to be secured in plastic bags (double plastic bags in the case of Ann Arbor) and then placed within the general waste collection receptacle. This is because of the smell and unhealthy nature of used diapers. The demand for secure packaging of diaper waste ready for collection is also made in Zimbabwe, with mothers reporting that Council refuse collectors refused to collect unpackaged diapers (Sola, 2014). Toronto has introduced a 'green bin' system where organic items and diapers go to a processing plant that makes them into compost, which is then distributed to parks and farmland (Grover, 2011).

An international rise in awareness of 'green' issues and demand for recycling has led to a debate on the impacts of disposable diaper use among concerned citizens. This debate is visible through numerous postings on environmental awareness and green websites. Much of what is posted is information from individuals wishing to share experiences of disposal initiatives. Discussion and experiences documented appear to be wholly from the MEDCs, where disposable diapers have been in common use for longer and choices have a wider range of facets. Recently more discussion on feasibility of disposable diapers within compost has

emerged (Grover, 2011; Priebe, 2014, fightbac.org, 2014). In these sites and similar others, writers are sharing experiments and methods they have tried as individuals for using diapers for compost.This forms a bank of information of varying quality, often interactive in nature and reflective of the seriousness of the issue.

There is also a significant volume of on-line discussion linked to the relative merits and problems associated with the disposable versus reusable diaper debate. Various life-cycle analytical approaches have been used to back arguments for or against each type of diaper. Serious life cycle analysis have mostly been undertaken by government agencies and consultants (Appropedia, 2011; Aumonier, Collins and Garrett, 2008 for the Environmental Agency; Rapson and Rolls, 2010). Life cycle analysis is complex as it is necessary to look at cradle to grave impacts which include water usage, raw material impacts, energy consumption during manufacture and use (washing machine for reusable diapers in MEDCs, and heating water in Less Economically Developed Countries LEDCs). These and many other impacts will vary considerably depending on the social, economic and physical environment at the place(s) of manufacture and use.

No comprehensive life cycle assessments were found that focused on LEDC countries or environments.

While legislation in some countries such as the United States of America, does specify diaper and sanitary waste, in many countries it is bracketed together with all other solid wastes. Between 1990 and 1992 twenty five U.S.A. 'States proposed actions regarding disposable diapers'(Crews, Rich and Niemeyer, 1994). The public and legislative concern over disposal of diaper products links to the rise in awareness of green issues and the visibly growing problem of solid waste in MEDCs. In Zimbabwe, diaper waste is not specified in the Environmental Management Act (EMA) 2002, falling broadly under part ix, sections 69 and 70, but not mentioned directly. However, 70(3) states that 'Every person whose activities generate waste shall employ measures essential to minimise wastes through treatment, reclamation and recycling' (EMA, 2002). There are no clear strategies on how this is to be done from a practical perspective and, therefore, this might be left up to an individual's awareness and commitment. Municipal Councils also may pass their own by-laws and produce their own strategies, but little seems to be documented or enforced. Public mobilisation to demand management strategies for particular forms of solid waste is in its infancy.

Municipal authorities do recognise such waste as a health hazard, but have no practical ways of dealing with it.

Few studies have been undertaken in Zimbabwe specifically relating to disposable diapers, their impacts and problems of disposal. Three were identified for this study. Two of these were pieces of undergraduate research undertaken from two State universities (Sola, 2014; Zamba, 2014). The other addressed environmental health impacts in Gweru (Mangizvo, 2014). General solid waste management is, however, widely researched. Clearly disposable diaper management is an area needing further and more extensive research.

Methodology

The study was primarily desk top, literature based, involving a comprehensive search to identify initiatives and strategies to deal with the problem of disposable diaper waste, being applied in various settings. This involved the use of wide search engines such as 'Google' and it's more academic brother 'Google Scholar'. It also involved accessing online journals and texts. The study was qualitative, enabling the researcher to access opinions and encourage discussion. Both information from academic research carried out in the

development of disposal of AHP waste and from on-line pressure group postings, blogs and discussions, mainly by mothers, were considered. The former could be considered to have academic substance, while informal online sources gave the researcher a sense of the grass root debate among mothers themselves. The initial research base was, therefore, very broad, however, it was by nature incomplete as it focused on a personal literature research which chose 'small samples or characteristics of cases according to the interests of the researches and subject requirements' (Lin, 2009). The research sought to analyse and synthesise information gathered. Having gathered information on disposal strategies an initial evaluation of their possible applicability or suitability for adaption into the Zimbabwean setting was made. Group discussion with mothers selected from groups of adult Zimbabwe Open University students in Bulawayo took place, with individuals being selected on a convenience basis. Discussions focused on choice of diaper use and personal experience of mothers on disposal issues. Opinions on possible strategies for dealing with diaper disposal and particularly on possible collection methods were also gathered. This direct information on feelings and opinions of diaper consumers, helped to balance against broader literature based information, and a tentative assessment of feasibility could then be made. It is important to recognise that this was just an initial study aimed at exposing options for diaper disposal and providing initial comments on applicability in the local environment.

Findings and discussion

Approaches to dealing with the problem generated by large volumes of disposable diaper waste are varied. There is a strong international lobby of environmentalists and others who believe that the way forward is to return to the reusable diaper in its original form or in various modified forms. There are others who are attempting to find ways of recycling used disposable diapers.The disposal of disposable diapers is of global concern and the need for research and development is reflected in the number of patents filed in this area, particularly by United States of American researchers. Most of these patents deal with design of diapers (example, patent no US20100280477A1, 2010) and also with separation of components (Example, patent no US4303501A, 1981) and with full management schemes (patent no US20060151497A1, 2006).

Developments and initiatives around the world

Identified approaches can, therefore, be placed under these two broad groups of return to usable diapers and recycling of used, disposable diapers.

Return to reusable diaper (nappy)

While there is some debate on this, the majority consensus is that reusable diapers are more environmentally friendly than disposable ones. As stated by Pham and Brown (2009:p.4) 'With reusable nappies all the urine gets processed as sewage; it does not get incinerated or landfilled. Individual reusable diapers typically get used lots of times; after their original users outgrow them, they get handed down not just to younger siblings ….when they have finally passed their useful life as diapers they tend to get reused as rags.' The main area of environmental impact lies in water usage (Pham and Brown, 2009) as frequent washing of diapers results in high levels of water usage.

Environmental sites such as Go Real believe that a return to the reusable diaper is the way forward. In order to make the use of reusables more user friendly

developments have taken place in diaper design and in laundry provision.

The traditional square toweling diaper is being replaced in many parts of the world by ready shaped and easy to use versions. A typical example is the 'pea pod' reusable nappy being marketed in Australia. This diaper is constructed as a shaped form with pop fastenings. It has a soft absorbent fleece inside and inserts are placed in the nappy to absorb excreta waste. More absorbent inserts are available for nighttime use. The washing procedure involves removing the soiling into the toilet and placing the absorber insert and nappy itself into a bucket for washing and subsequent reuse (buyeco.com, accessed September 2014). At Aus $19.95, this form of diapers is far more expensive than the old square foldable versions, but they are far easier to use and do not need extra purchases of waterproof over-pants. There are many similar diapers being sold in various countries in Europe and North America.

Designs for reusable adult diapers are also being generated. A prototype using terry cloth and fiberfill interlining was designed in Swaziland and underwent favourable tests. It is not known whether this was eventually manufactured (Zwane, 2010).

A great deal of money and resources are spent by the large multinational disposable diaper producers seeking to promote disposables (Hattingh, Russo, Sun-Basorun and van Walmalen, 2012; Rapson and Rolls, 2010). In order to convince mothers to use reusable diapers, ways to counter the advertising of the disposable companies and to make reusable diapers attractive to mother and baby, need to be sought. The Real nappy information service 'Go Real', in Britain, is attempting to provide information on real or reusable diaper use. While it grew out of the government's 'Real Nappy Campaign' it is now largely independent and counts 60 Local Authorities, 40 commercial real Nappy companies and 12 Community networks as members (Rapson and Rolls, 2010).

Go Real explains the advantages of reusable diaper use and attempts to encourage moving away from disposables towards reusable diapers. However, to counter the massive advertising presence of the disposable diaper companies, often through giving sample packs at clinics and hospitals, investment is needed. Rapson and Rolls (2010) state that schemes in New Zealand that have distributed nappy samples have achieved a 95% take up. Government and local authority involvement is also seen as very necessary if there is to be a change of usage pattern. Rapson and Rolls (2010) present a number of further suggestions including enforcement of green claims, further research and greater voluntary responsibility. The adoption of what is referred to as a 'big society' approach which would enable community groups to disseminate information and advice on behalf of local authorities is advocated as it was proven that more than half of parents trusted other parents, 39% local community nappy networks and only 7% local authority staff (Rapson and Rolls, 2010). This is indicative of how many people see those in authority or formal institutions as being removed from them and their daily concerns.

The time involved in laundering reusable diapers was a disincentive to their adoption in many populations around the world. In many large urban centres of Europe and North America, nappy/diaper laundering services have emerged to cater for those who prefer to use reusable nappies, but do not have the time, or wish to do the laundering at their homes. This usually involves a service that provides nappies and wraps at a fee (around £9 or £10 a week). A deodorised bin is provided and dirty nappies are collected, cleaned and returned to the household. Advantages cited are: less labour for the mother; lower consumption of water and detergent as bulk laundering is more economic in that respect and it is hygienic. Disadvantages lie in the weekly expense (which makes reusable diapers cost as much

as disposables to use): that the diaper bin may only be emptied weekly; and that the consumer can only use the type of diapers provided by the service (Baby Centre, 2010).

Use or Recycling of used disposable diapers

Utilisation of disposable diapers, either through power generation or forms of recycling is very much a new approach. Results of a search for recycling initiatives brings up two major companies both of which are expanding their recycling investment outside their initial countries of Canada (Knowaste) and New Zealand (EnviroComp).

In some places there has been construction of waste-to-energy plants. This has been particularly prevalent in the North-East of the USA. The plants produce electricity through burning of solid waste (Lehrburger, 1988). The levels of air pollution that may be generated make this controversial. However, it does ensure that dangerous viruses or bacteria are destroyed.

References

Appropedia, (2010). Cloth versus disposable diapers. http://www.appropedia.org/index.php?title=Cloth_versus_disposable_diapersandoldid=189661.

Aumonier,S, and Collins, M. (2005). Lifecycle assessment of disposable and reusable nappies in the UK. Environment Agency UK. www.environment-agency.gov.uk.

Aumonier,S, Collins, M, Garrett, P. (2008). An updated lifecycle assessment study for disposable and reusable nappies.Science report SC010018/SR2. Environment Agency UK. www.environment-agency.gov.uk.

Baby Centre, (2010). Using a nappy laundering service. http://www.babycentre, co,uk/a560107/using-a-nappy-laundering-service.

Buyeco, (2014). Pea Pods reusable nappies. http://www.buyeco.co.au/pea-pods-reusable-nappies.html.

Chikobvu, D. and Makarati, F. (2011). The challenges of solid waste disposal in rapidly urbanizing cities: A case of Highfield suburb in Harare. *Journal of sustainable development in Africa*, 13 (7), 184-99.

City of Ann Arbor Public Services (Michigan), (2013-2014). Waste Watcher. www.a2gov.org/recycle.

Crews, P.C, Rich, W, Niemeyer, S. (1994). A summary of environmental legislation targeting disposable diapers and review of related literature. *Journal of environmental polymer Degradation* 2 (1): 20-28

Deloitte LLP. (2011). Absorbent hygienic products comparative life cycle assessment. Knowaste Ltd.

Envirocomp, (2011). The history. http://www.envirocomp.co.nz/The-History.html

Fightbac.org 2014? Disposing of dirty diapers. www.fightbac.org.

Freyberg, T, accessed 2014. Nappy recycling is the UK ready to run, walk or crawl? Waste Management World.

Friends of the Earth. (2007). Residual waste research. EnviroCentre, Glasgow. www.envirocentre.co.uk.

Go Real. (2014). The real nappy information service. http://www.goreal.org.uk/why/environment/nappy-recycling.co.uk.

Grover, S. (2011). Toronto Green Bin. www.treehugger.com/lawn-garden/can-you-compost-dirty-diapers.html.

Hattingh, D, Russo, B, Sun-Basorun, A, and Van Walmelen, A. (2012). The rise of the African consumer. McKinsey and Company, South Africa.

Lehrburger, C. (1988). Out of sight, out of mind-the disposable nappy myth. Whole Earth Review.

Lin, G. (2009). Higher education research methodology-literature method.

International Education Studies, 2 (4):179-181 www.ccsenet.org/journal.html.

Mangizvo, M. V. (2014). The environmental health implications of the use and disposal of disposable child diapers in Senga/Nehosho suburb in Gweru city, Zimbabwe. *Global Journal of Biology, Agriculture and Health Sciences*, 3(2):122-27.

Mbiba, B. (2014). Urban solid waste characteristics and household appetite for separation at source in Eastern and Southern Africa. *Habitat International*, 43: 152-62. Elsevier Ltd.

Meseldzija, J., Poznanovic, D. and Frank, R. (2013). Assessment of the differing environmental impacts between reusable and disposable diapers. Dufferin Research.

Pep, P., (2013). Pep pride: facts October 2013.

Pham, NT and Brown, E W, 2009. Diapers and the environment. NEARTA. www.nearta.com.

Priebe, M. B. (2014). How to dispose of diapers and feminine hygienic products. www.ecolife.com.

Rapson, R. and Rolls, J., (2010) Reducing disposable nappy waste: review of waste policies-call to evidence, October 2010. Go Real, The Real Nappy Information Service.

Recycling Guide.org, 2014. Nappy recycler Knowaste to find large plant (Blog). February 7, 2014. http://www.recycling-guide.org.uk/blog-nappy-recycler-knowaste-to-find-a-large-plant.

RISI, (2014). Nappy recycling set to arrive in South Africa. RISI info, Pulp and Paper News, April 17. http://www.risiinfo.com/pulpand paper/news.

Schoch, R. M. (1996). Case studies in environmental science. Jones and Bartlett Learning.

Scoop, (2011). Agreement to sponsor composting for disposable nappies. Scoop Independent News, 9 November. Http://www.scoop.co.nz/stories / print.html

Smedley, T. (2014). Scotland's sustainable solution for recycling disposable nappies. Guardian, 22 January. http://www.theguardian.com/sustainable-business/recycling-used-disposable-nappies-scotland.

Sola, S. (2014). The use of disposable nappies and their accumulation as waste on illegal dumping sites in Pumula South. Undergraduate Research project, Zimbabwe Open University, Zimbabwe.

Zamba, B. F. (2014). Community participation in sustainable solid waste management in high density suburb; the case of Mbare, Harare, Zimbabwe. Undergraduate Research project, Midlands State University, Zimbabwe.

Zimbabwe Government, (2002). Environmental Management Act. Government Printers, Harare.

Zwane, P. E. (2010). Product development: reusable diaper. AUTEX research Journal, 10 (1) 31-34. http://www.autexrj.org/No1-2010/0332.pdf.